EVALUATION OF SEVERAL METHODS OF APPLICATION FOR DBCP ON PEANUTS [EVALUACION DE VARIOS METODOS DE APLICACION DEL DBCP EN EL MANI]

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ABSTRACT

A quantitative greenhouse study with DBCP incorporated into soil infested with *Meloidogyne arenaria* showed that dosages of 74.4 L/ha or higher were necessary for effective control of the parasite. In field experiments during the 1975 and 1976 seasons with Florunner peanuts, it was found that when DBCP was sprayed and disked in at planting time in a 36 cm band 18.7 L/ha or more were necessary to attain the same degree of control of *M. arenaria* and yield response as was obtained with a chiselled application of the fumigant at 9.3 L/ha. A field study was made with water emulsions of DBCP 86 EC at concentrations of 9-100% (v/v), each emulsion applied at 9.3 L/ha. Maximal control of *M. arenaria* was obtained with emulsions containing 75% (7.0 L/ha DBCP) of DBCP, and maximal yields were obtained with emulsions containing 50% (4.6 L/ha DBCP) of the fumigant. In a separate field study, during the 1977 season, several rates of DBCP (9.3, 14.0, 18.7, 37.4, and 65.4 L/ha), applied 70 days after planting were compared with the standard recommended planting time application of 9.3 L/ha for effectiveness against *M. arenaria* and yield response. Florunner peanuts tolerated all rates of DBCP applied postemergence without any sign of phytotoxicity. Yield response and control of *M. arenaria* with postemergence treatments were equal to that obtained with the planting time application. No differences occurred among postemergence treatments for nematode control or yield. Our results indicate that by modifications in the method of application, the amount of DBCP used could be considerably reduced without loss of effectiveness. The data also suggest that DBCP may be applied by several methods for control of nematodes on peanuts.

Key Words: 1,2-dibromo-3-chloropropane, peanut root-knot nematode, Arachis hypogaea, disease control, halogenated hydrocarbons.

INTRODUCTION

The fumigant 1,2-dibromo-3-chloropropane (DBCP) has been the standard nematicide used on peanuts in the Southeastern U.S.A. for the past 20 years. Typically, DBCP is injected at planting time using one or two chisels per row to deliver 7.0 to 9.3 L/ha (0.75 to 1.0 gal/acre) of the chemical. Much effort has been devoted to determine its relative efficacy against *Meloidogyne arenaria, M. hapla* and other parasitic nematodes of peanuts in comparison to other nematicides, and to improvements in the types of chisels for injection (1, 3, 7, 8, 11). However, despite its prolonged use, no information is available on other methods of application of DBCP to peanuts, on the tolerance of this crop to postemergence applications of the fumigant, or even of dosage necessary for effectiveness of spray-incorporation type applications of DBCP against peanut root-knot nematodes. This paper presents results of greenhouse and field experiments conducted to obtain this information.

MATERIALS AND METHODS

Greenhouse Studies. Soil used was a sandy loam from a field under peanut monoculture infested with *M. arenaria* (ca. 100 larvae/50 cm³ soil). The moist (60% field capacity) soil was passed through a 2mm-mesh sieve to remove large particles and was transferred in 500 gm quantities into polyethylene bags. Each bag received 10 ml of the appropriate concentration of DBCP water emulsion equivalent to: 2, 2.3, 4.6, 9.3, 18.6, 37.2, 74.4, 148.8, 297.6, and 595.2 L/ha of DBCP. The contents were mixed well and transferred to 11-cm-diam, 800 ml capacity, pots. Five Summer Crookneck Squash *Cucurbita pepo* L. seeds were planted in each pot to serve as indicator plants, since germination of peanut seeds is too irregular for use in greenhouse experiments. The pots were arranged in a completely randomized design with 8 pots per concentration. After six weeks of growth the plants were removed by careful washing and the number of galls on the roots and fresh root weights were determined. Degree of galling was also determined using a scale of 1 to 10 where 1 represented no galls and 10 extreme galling (13). The general appearance of the root systems was also evaluated using a scale of from 1 (healthy) to 5 (poor condition).

Field Studies. Experiments were conducted with Florunner peanuts during the 1975, 1976, and 1977 seasons in a field heavily infested with *Meloidogyne arenaria.* The soil was a sandy loam and the field had been under peanut monoculture for 5 years. Plots were 10 M long and two 0.92-M-rows wide. Treatments and controls in each experiment were replicated eight times in randomized complete blocks.

a. *Spray applications.* Two experiments were conducted to compare the effectiveness of spray-disk planting time applications of DBCP and the standard injection method. Spray applications were with the Fumazone® 86 EC formulation in water applied in 36 cm bands using a total volume of 160 L/ha. The material was incorporated with a single pass of a disk harrow. The injected applications were performed with the concentrate formulation using 2 chisels 20 cm apart per row. The 1975 experiment compared the performance of spray-disk applications at rates of 18.7, 28.0, and 37.4 L of DBCP/ha with the standard rate of 9.35 L/ha injected two chisels per row. The 1976 experiment compared the performance of spray-disk rates of 2.3, 4.7, 9.3, 14.0, 18.7, 23.4, 28.0, 37.4, and 65.4 L/ha; a planting time treatment of 9.3 L/ha of the fumigant applied using two chisels per row 20 cm apart was included in the test to serve as control since this is the recommended application method (2,7,8).

Variables studied. Nematode numbers were determined from soil samples collected during the first week of September prior to harvest. A total of 25, 3-cm-diam 20-cm-deep soil cores were collected from each plot. The cores from each plot were composited and a 50 cm³ subsample was taken for nematode extraction using a modified flotation-sieving technique (9,10). The relative appearance of plots was assessed in 1976 and 1977 just prior to harvest using a subjective scale which varied from a value of 5 representing excellent growth with total coverage of the plot surface, to a value of 1 representing poor growth with vines not covering the entire soil surface.

Plots were harvested during the first two or three weeks of September and yield from the entire plots was collected.

All data were analyzed following standard procedures for analysis of variance and differences between means were evaluated for significance with the modified Duncan's multiple range test (12). Unless otherwise stated differences referred to in the text were significant at the 5% or lower level or probability.

RESULTS AND DISCUSSION

Greenhouse Experiment. Results indicated that with the spray and mix type application used for this experiment DBCP was consistently effective in reducing the number

Table 1. Effect of DBCP 86EC rates on root development and *M. arenaria* on Summer Crookneck Squash in a greenhouse experiment.

DBCP rate (liter/ha)	Fresh root weight (mg)	Root condition*	Galling index**	No. gall root system	No. gall gm. fresh root
0	66.2 F***	3.31 AB***	2.76 AB***	48.3 A***	708.5 A***
2.3	74.3 EF	3.37 AB	2.80 AB	43.8 A	565.4 AB
4.7	94.2 CDEF	3.54 A	2.82 AB	48.6 A	496.1 BC
9.3	88.4 DEF	3.21 AB	2.34 BC	23.7 BC	275.3 D
18.7	99.4 DEF	3.23 AB	2.08 A	38.3 AB	362.9 DC
37.4	113.6 BCD	2.98 ABC	2.73 AB	35.8 AB	308.9 D
74.4	93.5 CDEF	2.91 BCD	1.71 CD	13.3 AB	130.9 E
148.8	120.4 ABC	2.54 DC	1.07 D	7.3 DC	59.4 E
297.6	147.5 A	2.32 D	0.25 E	0.7 D	6.9 E
595.2	140.3 AB	2.32 D	0.00 E	0.1 D	0.4 E

*Determined using a scale where 5 represented the poorest and 1 the best appearance.
**Index based on a scale where 1 represented no galls and 10 severe galling.
***Data are averages of 8 replications; values within columns with one or more letters in common are not statistically different (P: 0.05).

of galls per gram of root (GPG) at rates of 9.3 L/ha or higher (Table 1). While GPG numbers generally declined with increasing concentration of fumigant, differences at the 4 highest rates were not significant. Consistent reductions in galling index values, and reductions of over 80% in GPG values, with respect to the control, were obtained with rates of 74.4 L/ha or higher. Significant improvement in the root condition index was obtained with treatments of 148.8 L/ha or higher and DBCP treatments of 37.4 L/ha or higher with one exception (74.4 L/ha), resulted in increased fresh root weights when compared to the control.

Results from this experiment indicated that for DBCP 86 EC applied as a spray mix to be effective (80% reduction in GPG values) against *M. arenaria,* doses greater than 37.4 L/ha on a broadcast basis must be used.

Field Studies. a. *Spray-disk.* Spray-disk applications of DBCP at rates higher than 18.7 L/ha consistently reduced the number of larvae of *M. arenaria* (Table 2,3).

Table 2. Effect of spray-disk applications of DBCP 86EC on *Meloidogyne arenaria* population levels and Florunner peanuts in a field test, 1975.

DBCP rate (liter/ha)	Method of application	No. of Larvae per 50 cm^3 Soil	Yield (kgs/ha)
0	Spray-Disk	22.2 A*	1608 A*
18.7	Spray-Disk	14.7 AB	2183 B
28.7	Spray-Disk	8.4 BC	2026 B
37.4	Spray-Disk	1.0 C	2498 C
9.3	chisel	6.0 C	2327 C

*Data are averages of 8 plot replications; those followed by the same letter within a column are not statistically different (P: 0.05).

Table 3. Effect of spray-disk applications of DBCP 86EC on *Meloidogyne arenaria* population levels and Florunner peanuts in a field test, 1976.

DBCP rate (liter/ha)	Method of application	Subjective* appearance	No. of larvae per 50 cm^3 Soil	Yield (kgs/ha)
0		2.25 A**	19.1 A**	1447 A**
2.3	Spray-Disk	2.28 A	9.0 B	1223 A
4.7	Spray-Disk	2.28 A	5.8 B	1400 A
9.3	Spray-Disk	3.28 B	13.4 A	1920 B
14.0	Spray-Disk	3.00 B	12.2 A	1971 B
18.7	Spray-Disk	3.28 B	3.6 B	2064 B
23.4	Spray-Disk	3.50 B	4.1 B	2229 B
32.7	Spray-Disk	3.50 B	3.3 B	2512 C
37.4	Spray-Disk	3.36 B	2.0 B	2514 C
9.3	Chisel	3.28 B	1.3 B	2353 BC

*Based on a scale were 1 represented poorest growth and 5 best growth.
**Data are averages of 8 plot replications; those within the same column with a letter in common were not statistically different (P: 0.05).

Although some reduction was observed in 1976 with the 2.3 and 4.7 L/ha rates, we consider this spurious since in the same experiment the degree of protection obtained with rates of 9.3 and 14 L/ha did not differ significantly from the control. Chisel applications in 1975 and 1976 reduced the number of larvae of the parasite significantly below the control level. In 1976 spray-disk treatment at rates of 9.3 L/ha or higher significantly improved plot appearance equivalent to that obtained with the chisel treatment.

In 1976 all spray-disk treatments with rates of 9.3 L/ha or higher significantly increased peanut yields. In 1975 the 37.4 L/ha rate produced yields equivalent to the chisel treatment and in 1976 only those treatments with 9.3 L/ha or higher gave yields equivalent to the chisel treatment level.

Results from the spray-disk experiments indicate that it takes about 18.7-37.4 L/ha of DBCP applied in a 36 cm band to obtain both yields and control equivalent to a chisel application of 9.3 L/ha. This is expected when we consider the diffusion patterns for chisel and spray-disk applications. The pattern for chisel applications is pear-shaped and losses occur, at least initially, mostly through the chisel channel (4,5). In contrast, losses in spray-disk applications are more generalized since the fumigant is more uniformly distributed throughout the treated area. We therefore conclude that spray-disk applications, although effective and feasible, required 2-4 times as much DBCP as standard chisel applications.

DBCP rates used in the field were applied to a 36 cm band so that broadcast equivalent rates would be 2.57 times higher (row width: 92 cm). Thus, the minimal effective dosage for *M. arenaria* control in the 1975 experiment when expressed on a broadcast basis was 72.1 L/ha and that for 1976, 48 L/ha. These minimal dosages are within the range of effectiveness indicated by the greenhouse experiment which suggests that the spray-disk application of DBCP in the field can be simulated in spray mix greenhouse experiments.

Table 4. Effect of DBCP-water emulsions on *Meloidogyne arenaria* population levels and Florunner peanuts in a field test, 1977.

Percent (v/v) in the emulsion	DBCP 86EC (liter/ha)	Subjective* appearance	No. of larvae per 50 cm³ soil	Yield (kgs/ha)
100	9.3	4.5 C**	1.2 E**	4275 C**
83	7.6	4.5 C	2.1 E	4386 C
75	7.0	4.1 B	2.9 E	3960 C
50	4.6	4.6 C	11.4 D	4060 C
33	3.0	4.1 B	23.6 C	3585 B
25	2.3	3.8 B	16.7 CD	3439 B
9	0.8	3.4 AB	36.2 B	2644 A
0	0.0	3.0 A	43.4 A	2650 A

*Based on a scale where 1 represents the poorest growth and 5 excellent growth.
**Figures are averages of 8 replications; values within the same column with a letter in common were not statistically different (P: 0.05).

b. *Water emulsions.* Equal control was obtained with all water emulsions containing 75% or more of DBCP (Table 4). Differences in yields were not significant for treatments of emulsions containing 50% or more DBCP. These results suggest that there is a "saturation point" in the curve relating yield response and control to concentration of DBCP. Increased fumigant levels beyond that point did not increase yields. This point occurred at a rate of about 4.6 L/ha. These results also indicated that the recommended dosage of 9.3 L/ha for the standard chisel application is beyond this saturation point and consequently represents overdosing and waste of material. It is possible that application of DBCP in water emulsions may have increased the efficacy of this fumigant against *M. arenaria* by improving its fumigation pattern through an increase in the time which the fumigant remained in the soil. These results also indicate that a similar type behavior can be expected of other fumigants with similar solubility characteristics. Because of practical and environmental considerations we are at present testing water emulsions of other halogenated hydrocarbons to see if we can reduce recommended rates of use without loss of effectiveness.

Postemergence application of DBCP to Florunner peanuts did not produce any detectable phytotoxicity even at the highest rate used (65.4 L/ha). All postemergence treatments reduced larval populations to levels significantly below those found in control plots and in plots treated at planting time (Table 5). Plots receiving planting time applications had lower numbers of larvae than control plots. Differences in subjective appearance were not significant probably because in 1977 peanuts were not subjected to moisture stress during the latter part of the growing season. All DBCP treatments increased yields significantly above the control and there were no significant differences in yield responses among DBCP treatments.

These results are of practical importantce because they indicate that DBCP can be applied safely and efficaciously after planting. Success of the postemergence treatment is related to the relatively slow development of *M. arenaria* larval populations in infested peanut fields. Typically, larval populations in the top 20 cm of the soil profile are very low (0-5/50 cm³ soil) for the first 60 to 90 days after planting and increase sharply thereafter (6). Consequently, postemergence treatment during the early part of the

Table 5. Effect of planting and postemergence chiselled applications of DBCP 86EC on *Meloidogyne arenaria* population levels and Florunner peanuts in a field experiment, 1977.

DBCP rate (liter/ha)	Time of application	No. of larvae 50 cm^3 soil	Subjective appearance*	Yield
0	- - -	27 A**	4.45 A**	2895 A**
9.3	Postemergence	2 C	4.79 A	4033 B
14.0	Postemergence	0 C	4.79 A	3981 B
18.7	Postemergence	0 C	4.41 A	3759 B
23.4	Postemergence	0 C	4.75 A	3486 B
28.0	Postemergence	0 C	4.77 A	3715 B
37.4	Postemergence	0 C	4.56 A	3784 B
65.4	Postemergence	0 C	4.62 A	3691 B
9.3	Planting	16.0 B	4.80 A	3761 B

*Based on a scale where 1 represented the poorest growth and 5 the best.
**Data are averages of 8 replications; values within the same column with a letter in common were not statistically different (P: 0.05).

season can be expected to be as efficacious, or more so, than an equivalent treatment at planting time.

Results obtained for DBCP on peanuts can not at present be of practical use to farmers in the USA because of the recent ban on the use of this chemical on the crop. However, the similarities in properties between this chemical and other fumigants still in use, such as ethylene dibromide, suggest that the ideas developed in these studies for DBCP could be transferred to other fumigants. This is currently being investigated.

RESUMEN

Un estudio dosimétrico de invernadero reveló que dosis de 74.4 L/ha o más altas de DBCP son necesarias para obtener un combate efectivo del *Meloidogyne arenaria* cuando el nematicida se añade al suelo por aspersión con incorporación inmediata. Dos experimentos de campo también indicaron que cuando el DBCP se aplica durante la siembra por aspersión en una banda de 36 cm incorporándose seguidamente con un pase de discos, son necesarias dosis de 18.7 L/ha o más concentradas para obtener un combate de *M. arenaria* y rendimientos de maní similares a los obtenidos con una inyección durante la siembra de 9.3 L/ha del fumigante. Otro experimento de campo con emulsiones acuosas de DBCP de concentraciones entre 9 y 100% (v/v) del fumigante reveló que cuando se inyectaron las emulsiones a razón de 9.3 L/ha se obtuvo un cambate óptimo de *M. arenaria* con las emusiones de concentración del 75% o más altas pero que, sin embargo, no hubieron diferencias en rendimiento de maní entre los tratamientos con emulsiones de 50% DBCP o más concentradas. En un experimento de campo durante la campaña de 1977 se comparó la efectividad de aplicaciones por inyección de DBCP en varias concentraciones (9.3, 14.0, 18.7, 23.4, 37.4, y 65.4 L/ha) efectuadas 70 días después de la siembra, con la obtenida con la aplicación también por inyección, de este material durante la siembra en dosis de 9.3 L/ha. El maní Florunner demostró tener una alta tolerancia para el DBCP inyectado en la postsiembra ya que

no hubieron síntomas de fitotoxicidad con ninguna de las concentraciones estudiadas. El aumento en el rendimiento y la efectividad contra *M. arenaria* de los tratamientos de postsiembra fueron tan buenos como los obtenidos con el de la siembra sin que se registrasen diferencias significativas entre los de postsiembra. Los resultados señalan que el DBCP puede ser utilizado en el maní a dosis muy inferiores a las de uso corriente sin perder efectivida contra *M. arenaria* o rendimiento, siempre que se efectuen cambios en el método de aplicación de este material al suelo. Los datos obtenidos también sugieren que DBCP tiene propiedades que permiten el uso de técnicas variadas de aplicación para el maní.

Claves: 1,2-dibromo-3-cloropropano, nematodos noduladores, Arachis hypogaea, combate de enfermedades, hidrocarburos halogenados.

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CONTROL OF ROOT-KNOT NEMATODES ON PEANUTS WITH PLANTING TIME AND POSTEMERGENCE APPLICATIONS OF ETHYLENE DIBROMIDE AND AN ETHYLENE DIBROMIDE-CHLOROPICRIN MIXTURE [COMBATE DEL NEMATODO NODULADOR EN EL MANI CON APLICACIONES EN LA SIEMBRA Y LA POSTSIEMBRA DE BIBROMURO DE ETILENO Y DE UNA MEZCLA DE BIBROMURO DE ETILENO CON CLOROPICRINA].

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ABSTRACT

Field studies were conducted during 1977 and 1978 to determine the feasibility of using ethylene dibromide (Soilbrom 90®EC) or an ethylene dibromide-chloropicrin mixture (Terr-O-Cide®72-27) as substitutes for DBCP (1,2-dibromo-3-chloropropane) for control of root-knot nematodes on the Florunner cultivar of peanut *(Arachis*